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CASE REPORT

RESIDENTS CASE REPORT: MUSCULOCUTANEOUS NERVE INJURY IN A COLLEGIATE BASEBALL PITCHER

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ABSTRACT

Background: Literature regarding musculocutaneous nerve injuries among the athletic population is scarce, with only several reported clinical cases among baseball and softball pitchers.

Purpose: To present a unique case of a musculocutaneous nerve injury to aid in clinician awareness and propose innovative rehabilitation practices that may facilitate improved patient outcomes during recovery.

Case Description: A 23-year-old Division 1 NCAA collegiate baseball pitcher presented with vague anterior arm pain following a pre-season game. The athlete described the pain as an "intense stretch" of his right arm that occurred during his last pitch. The initial evaluation identified tenderness over the right distal bicep. All shoulder and elbow orthopedic tests to assess shoulder impingement, labral pathologies, and glenohumeral instability were unremarkable. Increased neural tension was also noted with upper limb neurodynamic testing of the median and ulnar nerves on the right arm compared bilaterally. Electromyography (EMG) testing confirmed a right upper and mid-brachial plexus stretch injury with the primary involvement of the musculocutaneous nerve. Rehabilitation focused on restoring strength deficits and diminishing neural tension. Blood flow restriction (BFR) was introduced on the uninvolved limb to reduce deficits in bicep musculature strength. Once the athlete regained bicep strength and forearm sensation, he was progressed from flat-ground throwing activities to throwing off the mound.

Outcomes: A reduction in neural tension during neurodynamic testing of the right arm, improvement of bicep brachii deficits seen between the right and left limbs, and restoration of sensation in the right lateral forearm enabled a progressive return to sport.

Discussion: Due to vague reports and inconclusive findings, the initial presentation of musculocutaneous nerve injuries may be mistaken for other conditions such as a biceps brachii strain. Further documentation of this injury and rehabilitation procedures are needed to enhance patient outcomes.

Key words: Baseball, blood flow restriction therapy, Movement System, musculocutaneous neuropathy, pitching

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BACKGROUND AND PURPOSE

The most common overuse neurological injuries that occur to throwing athletes are thoracic outlet syndrome, cubital tunnel syndrome, suprascapular neuropathy, or quadrilateral space syndrome.[1] Among baseball players, musculocutaneous nerve injuries are rare. Peripheral neuropathies related to sports participation account for approximately 6% of all neuropathies.[2,3] Injury to the musculocutaneous nerve distal to the innervation of the coracobrachialis has been reported, specifically after heavy exercise.[3] Symptoms may include lateral forearm and elbow pain, along with sensory loss over the distal volar forearm.[3] Isolated injury to the musculocutaneous nerve is a rare occurrence with few case reports available for review.[4–6] The presenting complaints are pain and weakness of the biceps brachii and brachialis muscles as well as numbness/paresthesia in the distal volar forearm.[3] Previous cases of musculocutaneous nerve injuries are documented among adolescent, high school, and professional baseball players.[4–6] The musculocutaneous nerve originates from cervical levels C5 and C6, converge to make the superior trunk, then create the anterior division and lateral cord, and ultimately terminates in the musculocutaneous nerve (Figure 1).[7,8] The nerve courses from the axilla, through the proximal aspect of the coracobrachialis, and proceeds laterally between the biceps brachii and brachialis to continue throughout the forearm and elbow.[7,9] The terminal portion of the musculocutaneous nerve then emerges laterally through the bicep's fascia approximately 4 cm proximal to the antebrachial fossa, providing the sensory function to the lateral forearm becoming the lateral antebrachial cutaneous nerve (LABC).[7] The LABC can be injured as a result of compression at this level as a direct consequence of repetitive forceful pronation of the extended elbow, which occurs with throwing.[3,7] Treatment strategies in these cases emphasized anti-inflammatories and rest.[4–6] Two cases have reported the use of physical therapy interventions; however, specific timelines, goals of treatment, and descriptions of included exercises were not reported.[5,6] Reported return to play timelines for the injury varied between 2-7 months.[4–6] To date, there are no published case reports that describe the use of blood flow restriction (BFR) training as a part of the intervention for musculocutaneous neuropathy in an overhead athlete. The purpose of this care report is to present a unique case of a musculocutaneous nerve injury to aid in clinician awareness and propose innovative rehabilitation practices that may facilitate improved patient outcomes during recovery. The subject gave informed consent to participate in this case report and was informed that de-identified information on his case would be submitted for publication.

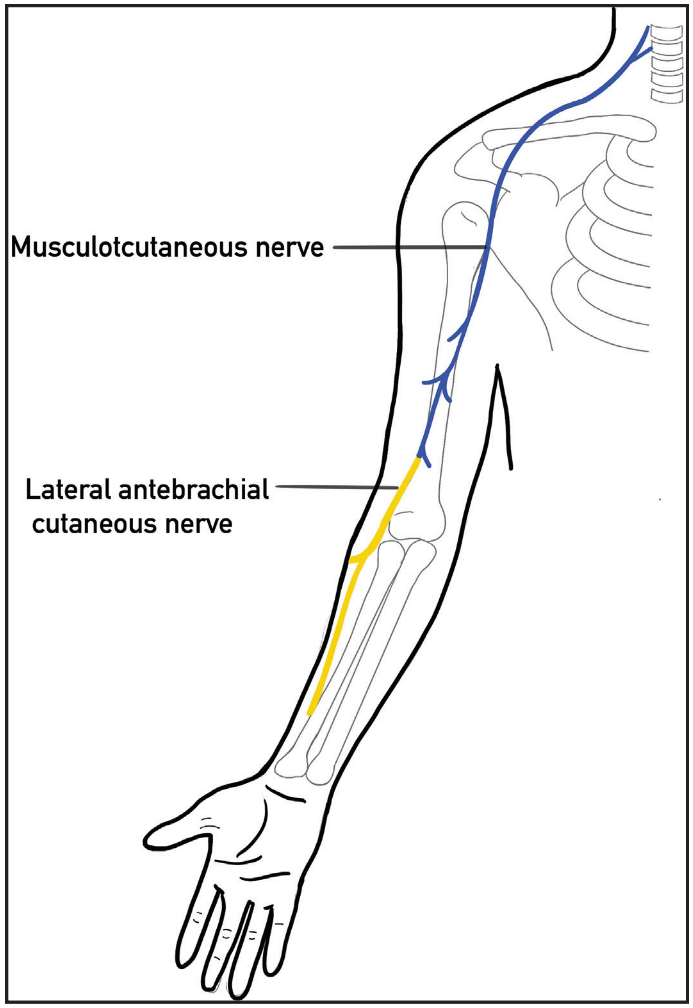

Figure 1. *Anatomical drawing of the musculocutaneous nerve pathway.*

CASE DESCRIPTION

A 23-year-old, Division 1 baseball player presented to his athletic trainer complaining of right arm pain after pitching during a pre-season game. The athlete reported feeling an "intense stretch" through his arm after releasing a pitch. The athlete also noted general soreness of his biceps musculature after releasing the ball. The athlete did not report any previous history of injury or relevant medical history.

CLINICAL IMPRESSION #1

The athlete's primary complaint upon initial examination was soreness and weakness of his right biceps musculature. Palpation of the athlete's right bicep musculature and subclavicular fossa were mildly tender. Internal and external rotation range of motion (ROM) measurements were measured bilaterally in the supine position with the arm elevated to 90 degrees in the scapular plane with the scapula stabilized by the examiner while the arm was passively rotated to end range. Measurements were taken using a digital inclinometer in a vertical direction with the axis of the goniometer aligned with the olecranon process. Glenohumeral internal rotation deficit was calculated by comparing the amount of internal rotation of the throwing arm to that of the non-throwing arm. Shoulder total range of motion (TRM) was calculated by adding the amount of internal and external rotation for each shoulder. Side to side differences in TRM were based on comparing the throwing arm to the non-throwing arm with a negative value indicating lesser TRM for the throwing arm. This method has been described in other reported studies.[10–12] Range of motion found during the initial examination for internal rotation (IR), external rotation (ER), and TRM for each arm is detailed in Table 1. The athlete also demonstrated a humeral torsion difference of 29 degrees between his throwing arm and non-throwing arm. A GIRD of 35 degrees was noted in his right shoulder. Humeral retroversion was assessed using a indirect ultrasound technique where the athlete was positioned supine with 90 degrees of shoulder abduction and elbow flexion. The primary examiner then used one hand to apply the diagnostic ultrasound (SonoSite FujiFilm Edge ultrasound system) head over the anterior aspect of the shoulder at the deepest point in the bicipital groove and in the plane of the treatment table. This position was verified with a digital inclinometer and aligned perpendicular with the long axis of the humerus in the frontal plane. The examiners other hand was used to rotate the forearm until the bicipital groove appeared in the center of the ultrasound image and the apexes of the greater and lesser tubercles were parallel to the horizontal plane. Once the greater and lesser tubercles were determined to be parallel, the second examiner used the digital inclinometer to measure the amount of humeral torsion. This method is similar to methods described in previous research studies.[13] Previous studies have indicated that humeral torsion contributes significantly to GIRD and increased ER ROM in baseball players.[13] Results of manual muscle testing (MMT) during the initial examination are detailed in Table 1. The only deficits that existed were in external rotation and elbow flexion strength, with both rated as a 4/5. Shoulder and elbow orthopedic tests were performed to rule out various conditions, including shoulder impingement, labral pathologies, and glenohumeral instability, which were unremarkable. Table 2 lists the selected orthopedic tests performed and their associated findings. Due to a lack of significant findings upon initial examination, a grade two strain of the biceps brachii was postulated as the initial pathoanatomical diagnosis. The athlete was treated with ice, anti-inflammatory medications, and instructed to rest and refrain from activity for the remainder of the day. The athletic trainer scheduled a follow-up examination for the next day.

Table 1. *Initial examination findings. ROM = range of motion, IR = internal rotation, ER = external rotation, TRM = total range of motion, MMT = manual muscle testing, Ext = extension*

Injured Extremity ROM (R Arm)	Uninjured Extremity ROM (L Arm)
IR 25 degrees	IR 60 degrees
ER 105 degrees	ER 75 degrees
TRM 130 degrees	TRM 135 degrees
Injured Extremity MMT (R Arm)	**Uninjured Extremity MMT (L Arm)**
Abduction 5/5	Abduction 5/5
ER 4/5	ER 4/5
IR 5/5	IR 5/5
Elbow Flx. 4/5	Elbow Flx. 4/5
Elbow Ext.5/5	Elbow Ext. 5/5

Table 2. *Orthopedic Special Test Findings*

Orthopedic Test	Associated Pathology	Findings
Neers	Shoulder Impingement	Not Painful
Hawkins Kennedy	Shoulder Impingement	Not Painful
Gerber's liftoff	Rotator Cuff Tear	Not Painful
Horizontal Adduction	AC Joint/Shoulder Impingement	Not Painful
Whipple's Test	Glenoid Labrum Tear	Not Painful
O'Brien's Test	AC Joint/ Glenoid Labrum Tear	Not Painful
Speed's Test	Bicep Tendonitis/Labral Tear	Not Painful
Jobe's Test	Rotator Cuff Tear	Not Painful
Dynamic Labral Shear Test	Glenoid Labrum Tear	Not Painful
Bicep Load Test	Glenoid Labral Tear	Not Painful
Shoulder Apprehension Test	Shoulder Instability/Labral Tear	Not Painful
Military Brace Test	Thoracic Outlet Syndrome	Painful/Diminished Pulse
Median Neurodynamic Tension	Neural Tension	Painful
Ulnar Neurodynamic Tension	Neural Tension	Painful
Radial Neurodynamic Tension	Neural Tension	Non-Painful

EXAMINATION

One day after the initial injury, decreased sensation was noted along the distribution of the athlete's lateral antebrachial nerve distribution in addition to the decreased strength of the elbow flexors and shoulder external rotators noted in the initial examination. Complete vascular compression occurred when the athlete performed the military brace test for thoracic outlet syndrome. The military brace test is a test for vascular compression of the neurovascular bundle between the first rib and clavicle. While the sensitivity and specificity of military brace test remains unknown, the Halstead maneuver, or the exaggerated military brace test is a similar orthopedic test that has been identified as a sensitive and specific test and is recommended for use in clinical practice.[14] Increased neural tension was also noted with upper limb neurodynamic testing of the median and ulnar nerves. The upper limb neurodynamic tests to identify cervical radiculopathy have been found to have high specificity and low sensitivity with reported sensitivity values ranging from 0.72-0.97 and specificity values ranging from 0.11-0.33.[15] The athlete reported increased numbness and tingling when placed in a position of 90 degrees of shoulder abduction, wrist and finger extension, forearm supination, and elbow extension for median nerve testing. Numbness and tingling were also noted when the athlete was positioned in 90 degrees of abduction, wrist and finger extension, supination, elbow flexion, and external rotation for the ulnar nerve. The findings identified with the military brace test and increased neural tension noted from upper limb neurodynamic testing led clinicians to believe the athlete had suffered a form of neural stretch pathology of the upper extremity. Therefore, the athlete's team physician ordered radiographic imaging, which was unremarkable. Based on these findings, a traction injury of the musculocutaneous nerve injury was suspected, and electromyography (EMG) testing was scheduled to confirm this finding. EMG and nerve conduction velocity studies are the gold standard instruments for diagnosis of neuropathy and are recommended in patients with persistent shoulder pain, atrophy, and weakness with no evidence of a rotator cuff tear.[16]

CLINICAL IMPRESSION #2

Results of the EMG confirmed a stretch injury to the athletes right upper and mid-brachial plexus with primary involvement of the musculocutaneous nerve. Significant asymmetric prolongation of the right musculocutaneous and axillary motor nerve latencies were seen across the right thoracic outlet and were measured as 6.3 msec and 5.8 msec, respectively. The typical upper limit reference values for the musculocutaneous nerve are 5.6 msec and 5.4 for the axillary nerve.[16] The athlete's physician confirmed the primary diagnosis of musculocutaneous nerve injury and recommended the athlete begin an oral steroid, refrain from throwing activities, and be started on a comprehensive rehabilitation program focused on regaining strength of the injured limb and decreasing neural sensitivity.

INTERVENTION

Restriction from throwing activities continued until the restoration of biceps musculature strength, decreased neural tension, and improved sensation of the lateral cutaneous nerve distribution occurred, which resulted in a loss of approximately 12 weeks of throwing activity. The athlete immediately began a comprehensive rehabilitation program that emphasized involved scapular stabilization, bicep and forearm strengthening, lumbopelvic stabilization, and hip strengthening while waiting for the musculocutaneous nerve to heal. Scapular muscle strengthening and stability exercises were selected to address the athlete's deficit in external rotation strength in the involved limb compared to the uninvolved limb. It is known that the scapular muscles play a vital role in the overhead throwing motion and rehabilitation recommendations in overhead pitchers emphasize targeting scapular stabilizers including shoulder external rotators, supraspinatus, trapezius, serratus anterior, and rhomboid muscles.[12] In this case, the athlete's care team believed that he had an increased head tilt and trunk lean while pitching that increased the athlete's risk for injury. Initially, exercises causing excessive stress on the biceps (e.g., eccentric contractions, abduction) and extension (e.g., biceps curls, dumbbell flies, pull-ups) were avoided to minimize further stretching of the musculocutaneous nerve. Table 3 denotes the exercises introduced within weeks 1-4 of rehabilitation.

BFR was introduced on the uninvolved side and lower extremities utilizing the cross-education theory after four weeks of rehabilitation in an attempt to reduce deficits in biceps strength by enhancing hypertrophy factors and increasing motor fiber recruitment.[17] The parameters of BFR use utilized within this patients care are detailed within Table 4. BFR use is associated with significant hypertrophy and strength gains with loads as low as 30% of 1RM.[17] Therefore, BFR has been a suggested tool, particularly in musculoskeletal rehabilitation in cases where higher strength training loads would not be ideal, including the early stages of the healing process.[17] Previous research has shown that the greatest increase in strength and girth measurement with BFR utilization occurs in the limb where the BFR tourniquet cuff is placed.[18] In one study evaluating the effectiveness of lower extremity BFR training within the limb of cuff placement, the contralateral limb, and controls, found improvements in strength and girth measurements in both the limb of BFR cuff placement and the contralateral limb compared to controls.[18] Strength increases of 8% in knee extension in the non-tourniquet BFR limb, 3% in the control group, and 15% in the BFR limb were seen. Whereas girth increases of 2.3% for thigh circumference in the non-tourniquet BFR limb, .8% for the control, and 3.5% for the BFR limb were seen.[18] While the improvements in girth and strength measures were most significant in the limb of cuff placements, small yet significant changes were still seen in the non-tourniquet limbs compared to controls. This improvement was speculated to occur via the cross-education theory.[18] The cross-education theory postulates that strength training of the uninjured extremity results in bilateral strength increases likely through neural adaptation mechanisms specifically, with eccentric contractions.[19,20] Strengthening the contralateral upper extremity limb and lower extremities with BFR were initially selected for this athlete due to the concern for adding the tourniquet-cuff on the involved limb during the initial stages of nerve healing. To date, there have been no reports of chronic long-term nerve damage reported in the literature associated with BFR use. However, BFR has been associated with patient reported numbness sensations and possible nerve conduction blockage from external compression which could potentially lead to ischemia.[21] Therefore, the clinicians felt that BFR application in the uninjured upper extremity and lower extremities may be advantageous for the patient to benefit from the potential cross-over effects that have been previously seen.[23] Application of the BFR to the uninjured and each lower extremity was performed with one cuff application at a time. The rehabilitation sessions utilizing BFR application began with the upper extremity followed by lower extremity application with one cuff on one lower extremity at a time.

Table 3. *A rehabilitation timeline and example exercises. BFR = bloodflow restriction therapy*

Rehabilitation Week	Example Exercises
Weeks 1-4	Upper body ergometer 5 minutes Rows 10 lbs. 3 sets x 10 repetitions (bilateral) FreeMotion machine resisted external rotation 5 lbs. 3 sets x 10 repetitions (bilateral) Military push ups 3 sets x 10 repetitions Bicep curl 20 lbs. 3 sets x 10 repetitions (uninvolved arm only) Theraputy (blue) Gripping x 5 minutes (involved arm only) TheraBand Finger extension 3 sets x 10 repititions (involved arm only) Shoulder shrugs 20 lbs. 3 sets x 10 repetitions (bilateral) TheraBand Clamshells 3 sets x 10 repetitions (bilateral) Theraband Bridges 3 sets x 10 repetitions Crunches 3 sets x 10 repetitions
Weeks 4-8	Previous weeks exercises and: BFR upper extremity exercises (2x per week- See Table 4) Uninjured limb only BFR lower extremity exercises (2x per week-See Table 4) Bilateral
Weeks 8-12	Previous weeks exercises and: BFR upper extremity exercises (2x per week-See Table 4) Performed bilaterally BFR lower extremity exercises (2x per week-See Table 4) Performed bilaterally Body blade Abduction 3 sets x 10 repetitions Internal 3 sets x 10 repetitions External rotation 3 sets x 10 repetitions FreeMotion Resisted D1 pattern throwing motion 5 lbs. 3 sets x 10 repetitions FreeMotion Resisted horizontal abduction 5lbs. 3 sets x 10 repetitions (bilateral) Eccentric bicep curls 10 lbs. 3 sets x 10 repetitions (bilateral) Serratus push ups Plank position 3 sets x 10 repetitions
Weeks 12+	Initiation of interval throwing program

BFR was induced using KAATSU® belts (Kaatsu training, Sato Sports Plaza Inc., Japan) applied to the athlete's upper thigh for lower extremity strengthening and the upper portion of the humerus just distal to the deltoid for upper limb strengthening. The KAATSU belts contain an electronic air pressure control system that monitors and sets optimal pressure for the individual patient at a rate of 1.3 times higher than resting systolic blood pressure (160-180 mmHg).[24] This is similar to previous studies that have used KAATSU units for BFR strengthening.[23] Table 3 denotes exercises that were performed within the in weeks 4-8 of rehabilitation. The BFR exercises utilized in weeks 4-8 are detailed within Table 4.

OUTCOME

Eight weeks following the athlete's initial injury, a second EMG study revealed a significant reduction of neuropathy findings. Latency measures were recorded as 5.1 msec for the musculocutaneous nerve

Table 4. *Details of BFR interventions*

Rehabilitation Week	BFR Exercises
Application	Upper extremity KAATSU band strapped just below deltoid insertion point KAATSU pressure adjusted to 320 mmHg 3 sets of 30 repetitions (max) performed for each exercise 30 seconds of rest allowed between each set 2 minutes of rest allowed between each exercise Weight selected for each exercise varied Weight was selected by patient to perform exercise to fatigue Up to 30 total repetitions 4 total exercises selected per session Lower extremity exercises (2x per week) KAATSU band strapped to superior thigh KAATSU pressure adjusted to 380 mmHg 3 sets of 30 repetitions (max) performed for each exercise 30 seconds of rest allowed between each set 2 minutes of rest allowed between each exercise Weight selected for each exercise varied Weight was selected by patient to perform exercise to fatigue Up to 30 total repetitions 4 total exercises selected per session
Weeks 4-8	Upper extremity example exercises (2x per week) Rows (uninjured arm) Resisted external rotation (uninjured arm) Manually Resisted shoulder Y's (uninjured arm) Bicep curls (uninjured arm) Tricep extensions (uninjured arm) Lower extremity exercises (2x per week) Double leg squats on shuttle (bilateral) Bulgarian split squat (bilateral) Russian deadlifts (bilateral) Calf raises (bilateral) Reverse lunges (bilateral)
Weeks 8-12	Upper extremity example exercises (2x per week) Rows (bilateral) FreeMotion Resisted external rotation (bilateral) Manually Resisted shoulder Y's (bilateral) Bicep curls (bilateral) Tricep extensions (bilateral) Chest fly Lower extremity exercises example exercises (2x per week) Knee extensions (bilateral) Double leg squats on shuttle (bilateral) Hamstring curls (bilateral) Bulgarian split squat (bilateral) Russian deadlifts (bilateral) Calf raises (bilateral) Reverse lunges (bilateral) Side lunges (bilateral)

and 4.1 for the axillary nerves, both of which are within regular latency references. However, while improvements were seen in reduced nerve latency and biceps brachii strength, a deficit in bicep brachii strength continued to be present with manual muscle testing being scored as 4+/5. The biceps brachii has a primary role as a stabilizer for the elbow and shoulder throughout the acceleration phase of pitching.[24] Due to his diminished neurotension findings, the athlete was allowed to progress through an interval-throwing program prescribed by the athlete's team physician (Table 5). This protocol was expedited based on the athlete's tolerance and tailored towards the athlete's injury compared to the physician's typical progression, which usually requires throwing at a specified number of feet for at least a one-week period rather than multiple stage progressions in one week with one day of rest. However, the

Table 5. *Interval Throwing Program*

Rehabilitation Week	Example Exercises
Weeks 1	Day 1: 1 set of 25 throws at 90 feet* Day 2: 2 sets of 25 throws at 90 feet* Day 3: 3 sets of 25 throws at 90 feet* **At least one day of rest between throwing days
Week 2	Day 1: 1 set of 25 throws at 105 feet* Day 2: 2 set of 25 throws at 105 feet* Day 3: 3 sets of 25 throws at 105 feet* *At least one day of rest between throwing days
Week 3	Day 1: 1 set of 25 throws at 120 feet** Day 2: 2 sets of 25 throws at 120 feet* (hat drills)* * At least one day of rest between throwing days **Required physician clearance to begin this level
Weeks 4	Day 1: 3 sets of 25 throws at 120 feet* Day 2: 1 set of 25 throws at 120 feet (hat drills)* 1 set of 25 throws from the mound Day 3: 1 set of 25 throws at 120 feet (hat drills)* 1 set of 25 throws from the mound *At least one day of rest between throwing days
Week 5	Day 1: 1 set of 25 throws at 120 feet (hat drills)* 1 set of 25 throws from the mound Day 2: 1 set of 25 throws at 120 feet (hat drills)* 1 set of 25 throws from the mound Day 3: 1 set of 25 throws at 120 feet (hat drills)* 1 set of 35 throws from the mound Day 4: 1 set of 25 throws at 120 feet (hat drills)* 1 set of 35 throws from the mound *At least one day of rest between throwing days
Week 6	Day 1: 1 set of 25 throws at 120 feet (hat drills)* 1 set of 35 throws from the mound Day 2: 1 set of 25 throws at 120 feet (hat drills)* 1 set of 35 throws from the mound Day 3: 1 set of 25 throws at 120 feet (hat drills)* 1 set of 40 throws from the mound Day 4: 1 set of 25 throws at 120 feet (hat drills)* 1 set of 40 throws from the mound
Week 7	Day 1: 1 set of 25 throws at 120 feet (hat drills)* 1 set of 40 throws from the mound Day 2: Bull pen (10 minutes)** **end of formal interval throwing program

athlete was prohibited from mound throwing until improvements in biceps strength were improved to a 4+/5 on MMT or better. BFR rehabilitation sessions continued to be completed two days per week in-between days of progressive resistive exercises. At this time, BFR was applied to the involved limb due to diminished neurotension signs and decreased concern for the potential adverse neural effects that may occur with BFR use.[21] Exercises performed during weeks 8-12 of rehabilitation are outlined in Table 3. While the athlete never regained full sensation of his lateral cutaneous nerve, he did experience continued resolution of neurotension findings and increased bicep brachii strength to 4+/5 on MMT. Therefore, the athlete was allowed to continue to progress in his interval-throwing program 12 weeks after the initial injury and was cleared to begin throwing off the mound by his team physician.

DISCUSSION

Neuropathies account for 2% of all causes of pain and weakness of the shoulder.[1] The initial presentation of peripheral nerve injuries may be mistaken for other conditions such as muscle strains, rotator cuff tears, or other neurologic conditions such as cervical radiculopathy and may further complicate definitive diagnoses.[1] Literature regarding the management and recovery timelines of musculocutaneous nerve injuries among baseball players is limited with time loss reports ranging from two to six months.[4–6] Healing rates for peripheral nerves are highly variable, ranging from weeks to years, depending on the location of neural compromise and classification of neuron degeneration.[26,27] Proximal neuron segments may heal at a rate of 2-3mm/day, whereas distal regeneration may occur at a slower rate of 1-2mm/day.[26] Peripheral nerve traction injuries often result in neuropraxia which is classified as focal demyelination without axon or connective tissue damage and reduction in conduction velocity.[28] From a biomechanical perspective, overstretching of the musculocutaneous nerve may occur in the pitching motion at the time of ball release due to the traction force placed through the arm as it attempts to decelerate thus placing excessive stress on the anterior shoulder including increased stress through the bicep musculature.[29,30] The amount of shoulder abduction, horizontal abduction, and elbow torque reached before ball release has been shown to affect the amount of traction force placed through the arm.[31,32] In this case, the athlete's care team believed that he had an increased head tilt and trunk lean while pitching that increased the athlete's risk for musculocutaneous nerve injury. Unfortunately, because the athlete's injury occurred during pre-season, no photo or video evidence was available to confirm this finding. However, the athlete's physician verbally recommended that the athlete avoid excessive head tilt and trunk lean when returning to throwing activity to prevent potential added stress on the musculocutaneous nerve. The care team was able to monitor the athlete and provide verbal cueing throughout the athlete's progression of the interval throwing program. Ultimately, unforeseen circumstances resulted in the athlete becoming unaffiliated with the team shortly after return to activity. Therefore, the athlete's care team was unable to provide an in-depth biomechanical evaluation and adjustment of the athletes pitching technique following completion of the return to throwing protocol.

This case report is unique as it adds to the documentation of proposed treatment strategies of musculocutaneous nerve injuries among the athletic population, including the use of BFR to reduce the potential for prolonged weakness of the injured limb. The use of BFR in previous literature has shown increased hypertrophy factors, whereas bilateral neural adaptations have been seen when strength training is introduced in the uninjured limb through the theory of cross-education.[17,19,20] There was a concern for BFR use initially on the involved limb based on previous literature that has cited reports of negative neural symptoms associated with BFR application.[19,26] However, BFR was eventually applied to the affected limb in weeks 8-12 when the patients nerve symptoms had diminished and neurotension signs became negative. In the time leading up to weeks 8-12, the patients care team utilized BFR training in bilateral lower extremities and the contralateral upper extremity in an effort to stimulate muscle hypertrophy and strengthening effects that have been seen with BFR application.[32,33] It is unclear whether the inclusion of BFR resulted in improved patient outcomes due to the lack of objective strength measures in this report and the inability to compare results to previously reported cases of musculocutaneous nerve injuries that included vague rehabilitation procedures. However, in this case, the athlete consistently reported that the BFR treatments were the only exercises that elicited the sensation of a sufficient workout stimulus. The exercises selected for this patient included comprehensive whole body strengthening emphasizing scapular stabilizers integral to the pitching motion and lumbopelvic hip strengthening to address the importance of the lower extremities role in the integrated biomechanical task of pitching.[11,34]

CONCLUSIONS

This case report is the first to detail a rehabilitation protocol for treatment of a musculocutaneous nerve injury in a collegiate pitcher, which may be a beneficial reference for clinicians who may encounter this pathology. Further research on the efficacy of BFR is needed, especially for upper extremity diagnoses as most of the literature is limited to lower extremity outcomes. Furthermore, the athlete was eventually able to return to pitching and full training without the onset of symptoms or recurrence of neurotension signs. Clinicians are advised to use their judgment as to whether or not the inclusion of BFR in the rehabilitation protocol of an injury such as this is beneficial based on the time and cost associated with this rehabilitation tool. Additionally, further reporting of clinical cases of musculocutaneous nerve injuries in athletic populations is needed in order to compare varied patient rehabilitation strategies and outcomes for this injury.

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